Dr. Vernon K. Krieble, assistant professor of chemistry at McGill University, succeeds Dr. R. C. Riggs as Scoville professor of chemistry at Trinity College, Hartford, Conn.

DISCUSSION AND CORRESPONDENCE

ELECTRICITY AND GRAVITATION

The action of gravitation on light is generally regarded as a continuous process but if we consider a ray of light as the limit of a chain of rectilinear rays for each of which the velocity has its upper limit value c, we can regard the gravitational action on the ray as built up of a succession of impulses, each of which changes the direction of the ray. To obtain a definite picture of this action, let us imagine the æther to be built up of electrical doublets travelling along straight lines with velocity c and sometimes colliding with one another. A collision in which the doublets break up and their constituents secure new partners leads to a temporary manifestation of free electric charge. For simplicity we shall suppose that this type of collision takes place only at points where matter is present and that such collisions occur continually so that the manifestation of free electric charge is permanent[1] and approximately steady. At a point not occupied by matter a collision may be supposed to result simply in a change in the direction of motion of the doublets. It is possible, however, that collisions are all of the first type. The elementary type of electromagnetic field is one in which a doublet breaks up into positive and negative constituents which fly away in different directions with the velocity c. The field of an electric charge moving with a velocity less than c can apparently be built up from such elementary fields by superposition and so the assumption of the fundamental character of the elementary field seems legitimate.

From the elementary fields it is possible to build up a type of field in which the electric charge associated with an electric pole fluctuates owing to the fact that the constituents of a doublet are in the neighbourhood of the pole at slightly different times. We shall assume that the electric action between two poles depends on the instantaneous values of the charges and shall endeavor to estimate the effect of the fluctuations. Let us assume that the total number of doublets which break up at an electric pole per unit time is proportional to the mass associated with the pole. This number will also be supposed to be the number of doublets which are created from the constituents of those which break up. Among the doublets which arrive at the second pole B there may be some that have come from A. Let us suppose in the first place that there is no gravitational shielding, then it seems reasonable to assume that the percentage of B's doublets which have come directly from A is proportional to the number which leave A and so is per unit time, proportional to the mass of A. The number of doublets which pass directly from A to B per unit time is thus proportional to the product of the masses of A and B. The doublets themselves will be supposed to be so small that the emission of the different doublets and the arrival of others may all be regarded as independent events. At an instant of time t when a doublet from A is arriving at B the charge on B may be then regarded as equal to $e' + f(t)$ when the charge on A at the earlier time $t - (AB/c)$ was $e - f(t)$. The function $f(t)$ is supposed to have a mean value equal to zero so that e and e' may be regarded as the mean charges associated with A and B respectively. The above expressions for the charges are supposed to hold only for the very short periods of time when the particular doublet under consideration is in the neighborhoods of B and A, at other times the values of the charges are governed by the presence of other doublets.

The mean value of the electric force between A and B over a small period of time, which is

[1] We imagine one component of a doublet to be momentarily separated from its fellow, when another doubtlet comes along the lonely charge secures a new mate and leaves another charge all alone, this charge behaves in a similar manner when it encounters another doublet and so on. In what follows we really consider collisions between doublets and free electric charges.

very large compared with the time during which a particular doublet is in the neighborhood of B, is proportional to $ee' - k^2$ where k^2 is the mean value of the square of $f(t)$ for all the doublets which pass from A to B and arrive at B in this interval. In accordance with our previous hypothesis it seems reasonable to conclude that k^2 is proportional to the product of the masses of A and B.

If in the interval of time from t to $t + dt$, no doublets arrive at B while a doublet left A in the corresponding interval $t - (AB/c)$ to $t + dt - (AB/c)$ it is clear that the mean value of the electrical force between A and B in this interval depends on ee' and there is no gravitational action. Other cases may be considered in a similar way and it is clear that the gravitational action depends only on the doublets which go directly from A to B. The action of B on A depends likewise on the doublets which go directly from B to A.

The present theory indicates that there may be a slight screening effect when a third body C is interposed between two bodies A and B, for C may be supposed to receive some of the doublets which would ordinarily go directly from A to B or vice-versa. The recent work of Nipher[2] and Majorana[3] thus becomes of additional theoretical interest when it is considered in the light of the present theory.

Gravitational action may be slightly modified, too, by collisions between doublets travelling with velocity c. In this connection it may be worth while to point out that if P and Q are two doublets travelling along different straight lines with velocity c, then after a certain instant it is possible for a particle travelling with velocity c to meet first one doublet, say P, and then Q but not for such a particle to meet first Q and then P. A series of moving doublets may thus be arranged in a definite order; something which happens to one doublet may affect those which come later in the series but not those which come earlier. This result may have some connection with the damping of oscillations in the emission of light. A more imperfect form of the present electrical theory of gravitation has already been published in *Proc. London Math. Soc.*, T. 18 (1919), p. 95, and in the *Messenger of Mathematics*, T. 48, p. 55. The possibility of a connection with the work of Einstein and Majorana has not been pointed out previously. The present theory seems to be free from the objections raised against the older electrical thory of gravitation (see O. W. Richardson, "The Electron Theory of Matter," p. 596), there may, however, be some other fatal objections to it.

H. BATEMAN

[2] SCIENCE, September 21 (1917).

[3] *Phil. Mag.*, T. 39, May (1920), p. 488.

PROTOZOA IN SAWDUST FOR CLASS WORK

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IN studying the method of excreta disposal by compositing night-soil with sawdust, the chance observation was made that microscopic examination of old sawdust piles revealed the presence of *Euglypha* cysts. Samples of sawdust were used for experimental culture of hookworm eggs and it was observed that the cultures showed profuse contamination with amœba, flagellates, ciliates, and free living nematodes. Samples from old sawdust piles were then moistened and incubated with the result that numerous specimens of protozoa and free nematodes were found.

The sawdust used was chiefly from southern pine.

This note is published with the thought that it may be of practical service to teachers in providing material for class work.

C. W. STILES
U. S. PUBLIC HEALTH SERVICE

CONCERNING DIASTROPHISM

Two papers have appeared during the current year which once again bring before American geologists the vexed question of systemic boundaries. In the first Böse[1] concludes that the ammonites found at Tularosa, New Mexico, 200 feet above the base of the Abo sandstone, are of Carboniferous age. This inter-

[1] Böse, E., *Am. Jour. Sci.*, Vol. 49, pp. 51–60, January, 1920.